Chapter 15
Precipitation

15-1. General.

The process of precipitation, its applications, and resulting waste streams are described in the first section of the chapter. The chapter's second portion is a hazard analysis with controls and control points listed.

15-2. Technology Description.

a. Process.

Precipitation is a treatment process in which soluble metals and inorganics are precipitated into relatively insoluble metals and inorganic salts by the addition of a precipitating agent (see Figure 15-1). Precipitates, which are small or colloidal, are then settled and/or filtered out of solution, leaving a lower concentration of metals and inorganics in the effluent. Precipitating agents include soluble hydroxide, sulfide, carbonate, and xanthate compounds. If the precipitate does not settle rapidly, a polymer may be added as a coagulant to increase agglomeration and settling. Inorganic iron and aluminum derivatives, such as ferric chloride and aluminum, may also be used to enhance coagulation. The solids are settled in a clarifier, and the supernatant liquid is discharged or sent to primary treatment. The thickened solids are then disposed of.

b. Applications.

Precipitation is a primary method of treating metal-contaminated aqueous waste streams. Most metals will precipitate from solution at some concentration of their hydroxide, sulfide, or carbonate salts. Additions of more soluble salts of these compounds to an aqueous stream may precipitate metals whose salts have a lower solubility than the additive ions.

Precipitation is a candidate technology for the remediation of groundwater contaminated with heavy metals (including radionuclides) and is an effective pretreatment method for other remediation technologies (such as chemical oxidation or air stripping) where the presence of metals may interfere with the treatment process.

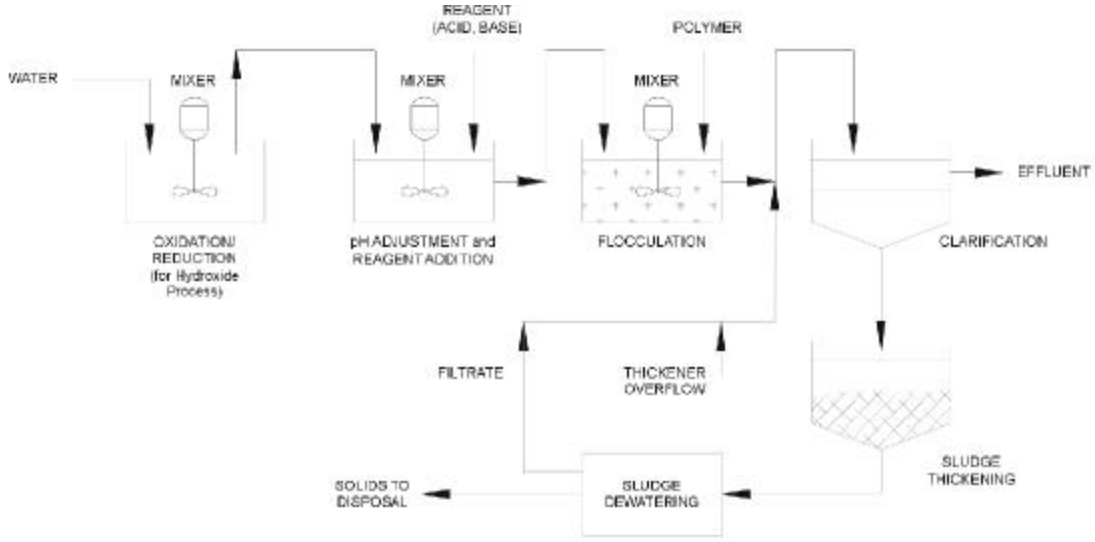

FIGURE 15-1. TYPICAL PROCESS FLOW FOR PRECIPITATION

c. Resulting Waste Streams.

Precipitation reactors will produce two streams that may require additional handling:

- The treated effluent wastewater stream.
- Sludges (such as metal hydroxide sludges) that must pass TCLP tests for land disposal.

Adequate solids separation techniques (such as clarification, coagulation, flocculation, and/or filtration) are required for efficient treatment. Treated effluent may be adversely impacted by the rate of addition of reagents or by pH adjustment, which must be controlled to prevent unacceptable concentrations of total dissolved solids in the treatment effluent.

For additional information on similar processes, see the Chemical Reduction/Oxidation (Chapter 18) and Ultraviolet Oxidation (Chapter 16) technologies.

15-3. Hazard Analysis.

Principal unique hazards associated with precipitation, methods for control, and control points are described below

a. Physical Hazards.

(1) Plugged or Overpressured Waste Lines.

Description: Solids from the precipitation process may plug waste lines if the rate of precipitation exceeds the rate of solids removal. Plugged waste lines may cause tanks to overflow, causing slippery conditions. Also, due to the wet environment and the use of electrical equipment, workers may be exposed to electrocution. Overpressure in lines may also rupture piping or pumps.

Control: Controls for plugged or overpressured lines include

- Use auger-equipped waste lines to help prevent plugged lines.
- Use flow controls to prevent plugged lines and overflowing tanks.
- Install hazard warning alarms to alert operators of system over-pressurization if necessary.
- Allow adequate space for maintenance between equipment.
- Verify that drawings indicate the hazardous area classifications as defined in NFPA 70-500-1 through 500-10.
- Use controls, wiring, and equipment, both temporary and permanent, that conform to EM 385-1-1, Section 11.G and NFPA 70 for the identified hazard areas.
- Use grounded equipment and/or equipment provided with ground fault interrupter circuit (GFIC) protection if required by EM 385-1-1, Section 11 or NFPA 70 requirements.
- Permit only trained and experienced workers in the areas.

CONTROL POINT: Design, Operations, Maintenance

(2) Emergency Wash Equipment.

Description: Emergency shower/eye wash equipment required per 29 CFR 1910.151 is not always provided with adequate floor drains, thereby creating potential electrical hazards or walking surface hazards during required testing/use.

Control: A control for emergency wash equipment includes

- Equip showers/eye wash equipment with accompanying functional drains to isolate and collect the shower/eye washwater from unprotected electrical equipment and walking surfaces that, when wet, create slipping hazards.

CONTROL POINT: Design

(3) Predesign Field Activities.
Description: Predesign field activities associated with subsequent construction may include surveying, biological surveys, soil gas surveys, geophysical surveys, trenching, drilling, stockpiling, contaminant groundwater sampling, and other activities. Each of these field activities may expose the survey personnel to physical, chemical, radiological, and biological hazards.

Control: Controls for hazards resulting from predesign field activities include

- Prepare an activity hazard analysis for predesign field survey activities. EM 385-1-1, Section 1.A provides guidance on developing an activity hazard analysis.
- Train workers in hazards identified.

CONTROL POINT: Design

b. Chemical Hazards

(1) Chemical Reagents.
Description: Precipitation treatment may expose workers to corrosive chemical reagents (e.g., HCL, lime, sodium hydroxide, carbonate salts, sulfide salts, etc.) used in the process. The reagents may be in powder or liquid form, and may pose an exposure hazard through either inhalation, dermal, and/or ingestion routes. These reagents may corrode piping system components. Some chemicals used in the precipitation process are hygroscopic (water absorbing) and may develop unwanted reactions in the presence of moisture.

Control: Controls for chemical reagents include

- Use a closed system for the delivery of chemical reagents (e.g., lime, sodium hydroxide solutions, etc.).
- Use personal protective equipment (PPE) such as an air-purifying respirator using cartridges appropriate to the reagents.
- Consult Material Safety Data Sheets (MSDS) prior to handling reagents to determine the specific chemical hazards and face shields, gloves, and aprons required.
- Store hygroscopic chemicals separately from other chemicals in airtight containers.
- Use appropriate materials in the design of piping and system components.

CONTROL POINT: Design, Operations, Maintenance

(2) Uncontrolled Reactions.
Description: If the addition of chemical reagents in oxidation/reduction reactions is not properly controlled, the reaction may cause a heat and pressure buildup that produces a system release. The release may involve worker

exposure to chemical reagents or waste material. Exposure may cause irritation or chemical burns to eyes, skin, and respiratory tracts.

Control: Controls for reactions include

- Use flow controls to help prevent addition of excessive amounts of chemical reagents (e.g., hydrochloric acid, sodium hydroxide, lime, etc).
- Store the oxidation/reduction reagents in separate areas under cool, dry conditions.
- Include pressure-relief systems and over-pressurization alarms as mandatory components in process design.
- Install an automatic shutoff to prevent the overflowing of storage tanks.
- Locate chemical piping low to the ground, if possible, in case of rupture.
- Provide insulation on pipes to prevent slipping hazards if pipes have moisture buildup.

CONTROL POINT: Design

(3) High pH Sludge.

Description: Sludge from the treatment process may have a high pH, which may cause skin burns for workers handling the material.

Control: Controls for high pH include

- Neutralize sludge prior to handling.
- Use PPE such as rain gear, rubber gloves (e.g., butyl rubber for hydrochloric acid or sodium hydroxide), and splash shields.

CONTROL POINT: Design, Operations, Maintenance

(4) Hydrogen Sulfide Exposure.

Description: The process may form metal sulfides, which may generate toxic (including hydrogen sulfide), or the sulfide sludge may spontaneously combust. If sulfide salts are used as a precipitating agent, hydrogen sulfide gas (H&S) will be generated if the solution is acidic.

Control: Controls for hydrogen sulfide exposure include

- Ventilate to remove gas from the work area, process tanks, and vessels.
- Use pH control to keep the sulfides alkaline.
- Use water control systems to keep sulfide filter cakes moist.
- Install a hydrogen sulfide (H_2S) monitor to avoid fatal overexposure where the generation of H_2S is most probable. Set monitors to alarm at 10 ppm.
- Make emergency escape respirators available for all operators in the event of a catastrophic system rupture or uncontrolled reaction.
- Train workers in hazard identification and control.

CONTROL POINT: Design, Operations, Maintenance

(5) Acids and Bases.

Description: Workers may be exposed to acids or bases used for pH adjustment.

Control: Controls for acids and bases include

- Construct secondary containment storage areas for acids and bases of compatible materials.
- Mark storage containers clearly.
- Store acids and bases in separate areas.
- Locate emergency showers and eye wash stations that comply with 29 CFR 1910.151(c) and the design requirements specified in ANSI Z358,1 (1990) near the reagent storage areas.
- Automate handling of pH agents to the extent practical.
- Prepare an emergency plan and train facility personnel to safely handle acids and bases.
- Restrict manual handling of acids and bases to personnel familiar with their properties.
- Use PPE such as leather or rubber acid-resistant boots, chemical-resistant coveralls, goggles and face shields, air-purifying respirators (as indicated by the reagent), and rubber or other acid and base resistant gloves (e.g., nitrile) or gauntlets.
- Train workers in safe acid/base handling techniques.

CONTROL POINT: Design, Operations, Maintenance

(6) Treatment Buildings.

Description: Permanent or semi-permanent treatment buildings may present life safety hazards such as inadequate egress, fire suppression systems, and/or emergency lighting systems.

Control: Controls for treatment buildings include

- Meet the following construction requirements for permanent and semi-permanent treatment system buildings: ANSI 58.1: Minimum Design Loads for Buildings and Other Structures; the National Fire Code; the National Standard Plumbing Code; Life Safety Code; and the Uniform Building Code.
- Make sure structures comply with either the Air Force Manuals on Air Force bases, the USACE Technical Manuals on Army installations, or local building codes on Superfund, BRAC, or FUDS sites.

CONTROL POINT: Design, Operations

c. Radiological Hazards.

Radioactive Materials.

Description: Many radioactive materials and naturally occurring radioactive materials (NORM) are metals and if present in the water may be precipitated out

and concentrated. This hazard may be considered out of the ordinary for this technology. Some radioactive materials may present an external exposure hazard. All radioactive materials may present an internal exposure hazard through inhalation or ingestion.

Control: Controls for radioactive materials include

- Consult a qualified health physicist to determine the exposure potential, any necessary engineered controls, or required PPE.

CONTROL POINT: Maintenance

d. Biological Hazards.

No unique hazards are identified.